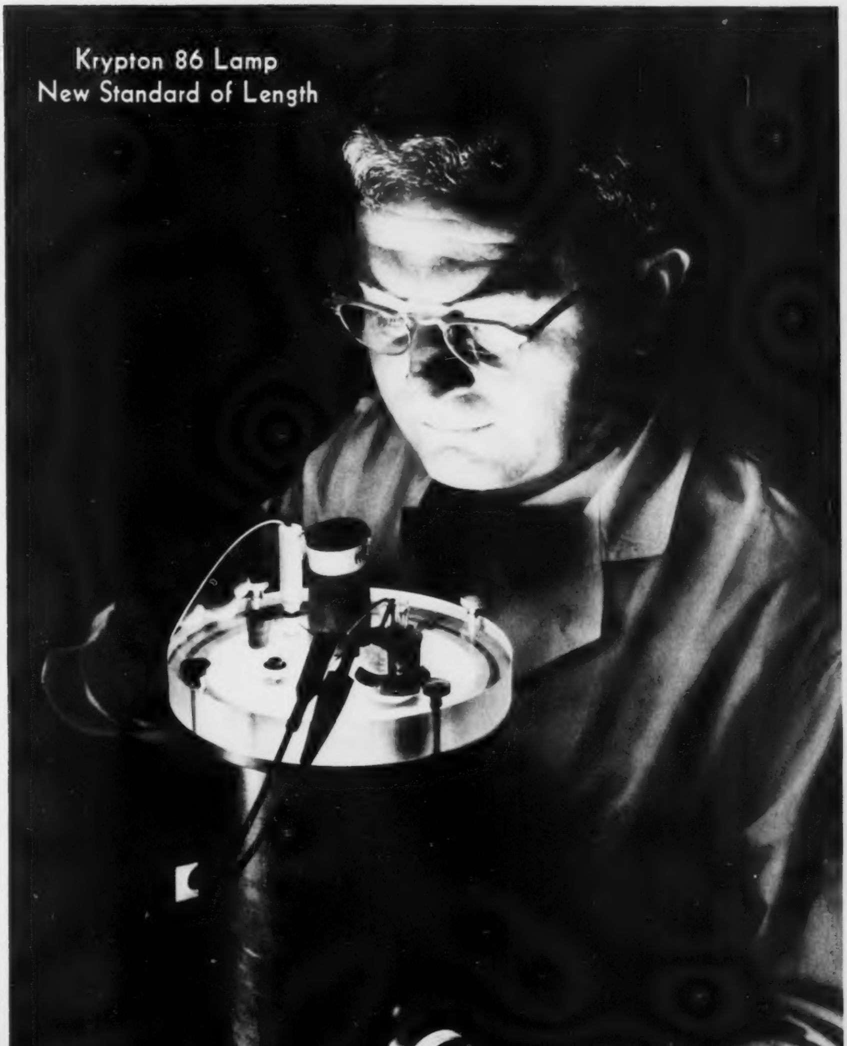
NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

VOLUME 44 DECEMBER 1960 NUMBER 12

Actions of the 11th General Conference on Weights and Measures



U.S. Department of Commerce — Frederick H. Mueller, *Secretary*

National Bureau of Standards — A. V. Astin, *Director*

NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Subscription price, domestic $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 24, 1958).

December 1960 — Issued Monthly — Vol. 44, No. 12

Contents

Cover: A National Bureau of Standards scientist adjusts a krypton-86 lamp in its liquid nitrogen bath. The wavelength of the orange-red light emitted by the lamp has just been adopted as the International Standard of Length. The lamp is operated at the triple point temperature of nitrogen, 63 °K, to improve the reproducibility of the standard wavelength.

Wavelength of Kr^{86} Light Becomes New International Standard of Length

ON October 14, 1960 the world adopted a new international standard of length—a wavelength of light—replacing the meter bar which had served as the standard for over 70 years. The action was taken by the 11th General Conference on Weights and Measures, which met in Paris.

Dr. Allen V. Astin, NBS Director, headed the American delegation to the Conference. The delegation also included Louis Polk, President, Sheffield Corporation; Elmer Hutchisson, Director, American Institute of Physics; A. G. McNish, Chief, Metrology Division, NBS; T. H. Osgood, U.S. Scientific Attaché, London, and Marten Van Heuven and Benjamin Bock, U.S. State Department.

Other actions taken by the Conference included the establishment of a central facility at the International Bureau of Weights and Measures for international coordination of radiation measurements, confirmation of a new definition of the second of time, and adoption of refinements in the scales for temperature measurements.

The new definition of the meter as 1,650,763.73 wavelengths of the orange-red line of krypton 86 will replace the platinum-iridium meter bar which has been kept at Paris as an international standard for length since 1889 under the Treaty of the Meter.

These actions of the General Conference are of great importance to those engaged in precision measurements in science and industry. For many years the world has relied on a material standard of length—the distance between two engraved lines on the International Meter Bar kept at Paris. Duplicates of the International Standard were maintained in the standards laboratories of other countries of the world. From time to time it was necessary to return these duplicates to Paris for recalibration, and occasionally discrepant results were obtained in these recalibrations. Also, there was doubt in the minds of some scientists regarding the stability of the International Meter Bar. The new definition of the meter relates it to a constant of nature, the wavelength of a specified kind of light, which is believed to be immutable and can be reproduced with great accuracy in any well-equipped laboratory. Thus it is no longer necessary to return the national standards of length to Paris at periodic intervals in order to keep length measurements on a uniform basis throughout the world. Also it is possible to measure some dimensions more accurately in terms of the new definition than was possible before. The meter bars which have served as standards of length throughout the world for over 70 years will not be discarded or placed in museums because of this decision, the Conference said. They will remain important because of the ease with which they can be used for certain types of measurement and for comparison measurements between national laboratories.

This new definition of the meter will not materially change the measurement of length nor in any way the relation between the English and Metric units. Careful experiments performed at the National Bureau of Standards by the team of A. G. Strang, K. F. Nefflen, J. B. Saunders, B. L. Page, and D. B. Spangenberg immediately prior to the meeting of the Conference confirmed that the wavelength standard and the metal standard are in satisfactory agreement. The inch now becomes equal to 41,929.399 wavelengths of the krypton light.

Similar measurements performed by the National Research Council in Canada, by Dr. K. M. Baird and his associates, are in substantial agreement with the National Bureau of Standards results. By adoption of the new definition, the standard of length which has been used by spectroscopists for the past 50 years is brought into agreement with that used in other branches of science, thus increasing the unification of systems of measurement throughout the scientific world.

The establishment of a central international facility for measurement of X-rays, radioactive isotopes, and neutrons will assure that all nations of the world will be able to make coordinated measurements of these radiations. To accelerate the planning of this major effort to establish worldwide standards of radiation measurement, the Ford Foundation has made a grant of $32,500 to the International Bureau of Weights and Measures which was accepted by the Conference. The Conference confirmed the action of the International Committee on Weights and Measures in defining the second of time as 1/31,556,925.9747 of the tropical year 1900 instead of 1/86,400 part of the mean solar day. The temperature of a mixture of ice and water at normal atmospheric pressure, used as a standard for temperature measurements for many years, was abandoned and replaced by the equilibrium temperature of ice, water, and water vapor, which is more accurately reproducible. The Conference also agreed to adopt the symbols SI (Système Internationale) to designate the system of units involving the meter, kilogram, second, ampere, candela, and related units, and named the unit of magnetic flux density in this system the "Tesla."

Future work of the Conference was laid out in

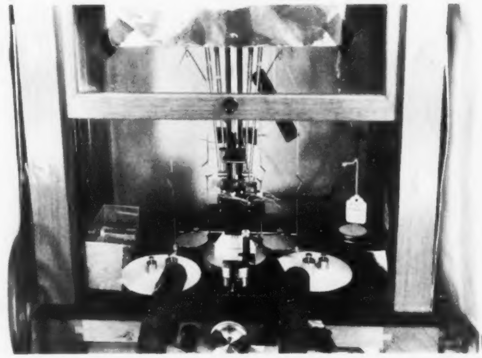
another series of resolutions. The major standardizing laboratories of the world were invited to continue their researches on standards for time interval based upon transitions between energy levels of atoms or molecules and the International Committee on Weights and Measures was invited to coordinate such results with the view to enabling the 12th General Conference to adopt a definition of the second based on one of these transitions to replace the present definition. The International Committee on Weights and Measures was also charged with studying and arriving at a conclusion on making the liter by definition exactly identical with the cubic decimeter and selecting the best value for the earth's gravity constant to replace the Potsdam value.

Humidity Effects on Microbalances

INVESTIGATION has shown that the rest point of microchemical balances may be seriously altered by changes in relative humidity.[1] H. E. Almer, of the mass and scale laboratory, found that enough moisture can collect on balance parts to move the pointer off scale. Careful design of balance components, selection of materials that absorb little moisture, and maximum cleanliness will minimize this effect.

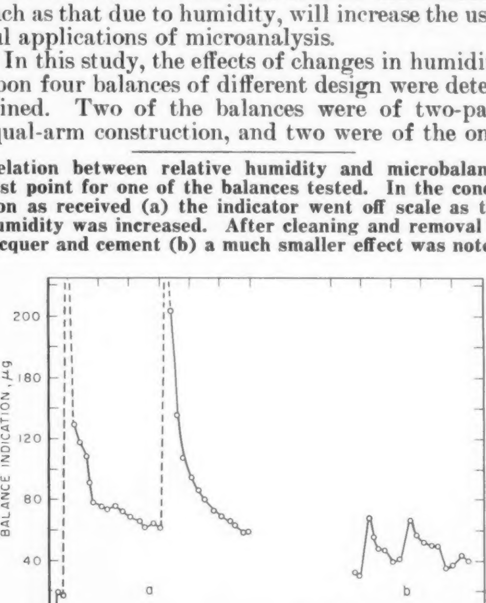
Traditional means of chemical analysis are being widely supplanted by milligram techniques, which offer the advantage of rapidity and economy. To gain even wider acceptance, however, the newer methods must offer the same degree of accuracy as those they replace. In microanalysis the errors due to weighing are often significant. The identification and reduction of these errors, such as that due to humidity, will increase the useful applications of microanalysis.

In this study, the effects of changes in humidity upon four balances of different design were determined. Two of the balances were of two-pan, equal-arm construction, and two were of the one-pan, direct-reading type. The humidity in the balance case was determined by an electric hygrometer. The balance indication was recorded for a short period to show the performance under room conditions. Moist air was then introduced into the balance case. After this the balance indication was recorded while the moisture escaped from the case and the air enclosed returned to ambient conditions. When large changes in rest point were noted, the balance was carefully cleaned, including the removal of lacquer and excess cement. The test was then repeated.



Equipment used to evaluate the effects of changes in humidity on the rest point of microbalances. To increase the humidity, air from the balance circulates through the hoses, over water, and back into the balance. After turbulence subsides, the humidity is read from an electric hygrometer (sensing elements in front, left corner of the case) and the rest point of the balance is determined.

Relation between relative humidity and microbalance rest point for one of the balances tested. In the condition as received (a) the indicator went off scale as the humidity was increased. After cleaning and removal of lacquer and cement (b) a much smaller effect was noted.



To determine whether certain balance parts were unusually sensitive to changes in humidity, they were weighed in a closed chamber, in which a pan was suspended by a wire from a balance above. The relative humidity in the chamber was altered, and any change in weight was detected by the balance. In this way the part could be checked at various levels of humidity without affecting the weighing instrument.

Each of the balances tested reacted to changes in relative humidity, reaching a new rest point quite rapidly. The magnitude of this change was different for each balance, one actually going off scale during the test. The effect on this balance was greatly reduced by removal of laquer and excess cement. The performance of another balance that showed large deviations improved after clean-

ing. Changes in rest point ranged from over 8 μg for each percent humidity change before treatment to 0.8 μg after treatment.

The investigation showed that moisture can collect on a balance through absorption by hygroscopic materials such as lacquer, cement, and dust, and by adsorption on all surfaces. To improve the performance of microbalances, the use of hygroscopic materials should be eliminated wherever possible, and balance parts should be kept free of foreign matter. Design considerations should include uncompensated differences in the coefficient of adsorption, and correction for inequalities in the surface area on either side of the beam.

The response of a balance to changes in relative humidity is unpredictable, and can be determined only by testing of individual instruments.

[1] **Response of microchemical balances to changes in relative humidity**, ***H. E. Almer, J. Research NBS* 64C, *281 (1960)*.**

Determining the Order of Chemical Reactions

A SIMPLE, rapid mathematical method[1] for determining the order of a chemical reaction has been devised by J. H. Flynn of the Bureau. When the order of a chemical reaction is known, the factors influencing the speed of the reaction can usually be determined. Thus, the method promises to be particularly useful to chemical engineers, industrial chemists, and other scientists concerned with controlling rates of reaction. The procedure may also be utilized to detect errors in initial conditions and stoichiometry; and in some cases it provides clues to the forms of complicated kinetic expressions.

When several compounds are mixed, many different reactions may take place. To obtain a good yield of any single substance, the temperature, concentration, and other conditions must be controlled so that one specific reaction will predominate. Information on the rates of the various intermediate reactions is of considerable value in establishing optimum values of these conditions.

In many cases the rate of a chemical reaction is determined by the concentration of the reacting substances. When the rate is directly proportional to the concentration of a single substance, the reaction is said to be of the first order. When the rate is proportional to the concentration of each of two reacting substances, then it is second order, and so forth. Zero-order reactions are those whose rates are influenced by some limiting factor other than concentration.

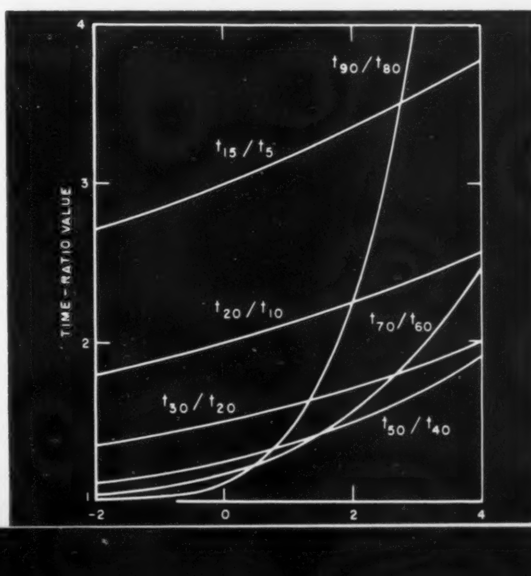
Although distinct first-, second-, third-, and zero-order reactions can be defined in simple terms, a large number of reactions do not follow a constant order throughout an entire series of steps. In fact, many chemical processes are complex, involving two or more simultaneous reactions.

Because of the complex nature of such reactions, the mathematical description of the overall process is the result of several rate expressions and consequently is difficult to obtain accurately. Although the Bureau method does not solve all the problems involved, it does simplify the fitting of data to mathematical expressions and provides information on the actual rate equation. In some cases, it permits interpreting deviations from constant order which are caused by errors in initial times and concentration, and by the reaction following a more complicated rate expression.

Bureau Method

The method of finding order is based on time-ratio tables which were calculated by the Bureau. For a given reaction, values were determined of the time t_x required for the reaction to reach x-percent completion. Successive overlapping ratio values (t_{15}/t_5, t_{20}/t_{10} . . . t_{95}/t_{85}) were then tabulated as a function of order to give the tables. Time-ratio values can be plotted as a function of order, as is done for several time-ratios. By using such a family of curves, fractional orders can be easily obtained.

To find the order of a chemical reaction by the Bureau's method, the degree of advancement of the reaction, i.e., the extent of the reaction completed, is obtained experimentally at specific intervals. This is done by measuring some physical or chemical property which is a known function of the concentration of a reactant or product. By plotting the different percentages of completion as a function of time and drawing a smooth curve through these points, values of the times for various degrees of advancement can be obtained. Then, by comparing different ratios of these times



Family of curves representing the dependence of time ratios on the order and extent of a chemical reaction. By using a simple mathematical method, which incorporates a time-ratio table, the order of a chemical reaction can be rapidly calculated.

to the time-ratio values in the Bureau table, the related order can be rapidly determined.

Not only because of its simplicity, but also because it involves only one subjective step—fitting the smooth curve to time-versus-concentration data—the method should prove to be valuable to chemists without highly developed mathematical backgrounds. It has some of the advantages of the more cumbersome "differential" expressions often used in kinetic analyses, in that it can be used to interpret deviations in the order. If the order does not follow a simple kinetic expression, the method may aid in recognizing this and in interpreting the correct expressions.

An induction period or initial period of rapid reaction, which may be too short to be recognized by other methods of kinetic analysis, will appear as an error in the initial time or concentration. To distinguish between an error in initial time and an induction period, a new degree of advancement can be calculated from an arbitrary point on the curve representing the concentration as a function of the time.

From the changes in apparent order for successive time ratios, approximate values for the parameters of a much more general type of differential rate equation can be obtained. This equation is applicable to data describing some reversible and simultaneous reactions as well as many catalytic and chain reactions, and may prove useful in preliminary kinetic investigations of a chemical system.

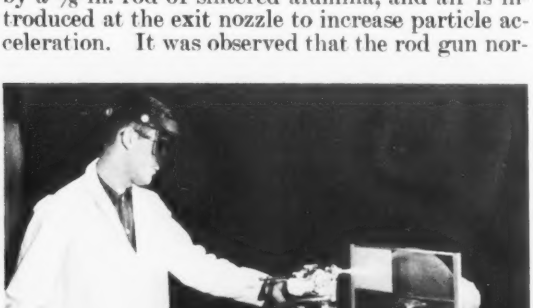
[1] *For further technical information, see* **Rapid determination of the order of chemical reactions by time-ratio tables**, *J. H. Flynn, Tech. Note 62, which may be obtained from the Department of Commerce, Office of Technical Services, Washington 25, D.C. (75 cents); see also J. H. Flynn, note in J. Phys. Chem.* **61,** *110 (1957).*

FLAME SPRAYING OF ALUMINA

THE BASIC principles involved in the flame-spray process of coating metals with alumina are being investigated by the Bureau for the Air Force. D. G. Moore, of the ceramic coatings laboratory, is directing the investigation. Potential uses of the heat-resistant coating produced by this process include the thermal protection of jet and rocket engine components and regulation of temperature within space vehicles. One of the determinants of coating structure is particle velocity; to study this variable, a rotating-disk velocimeter was developed.

Of the three current methods for applying coatings to metal by particle impact—namely, flame-spray, detonation, and plasma-jet—the flame-spray technique offers the advantages of mobility and relative ease of operation. Although the coating of parts by flame spraying has been practiced for many years, the application of alumina by this means is a relatively new development.

In flame-spraying alumina, two types of oxy-acetylene guns known as the "powder gun" and the "rod gun," are used to melt and propel the particles. In the powder gun, finely divided alumina is fed into the combustion zone, producing a continuous stream of particles. The rod gun is fed by a 1/8-in. rod of sintered alumina, and air is introduced at the exit nozzle to increase particle acceleration. It was observed that the rod gun normally produces bursts of particles, rather than a continuous stream.



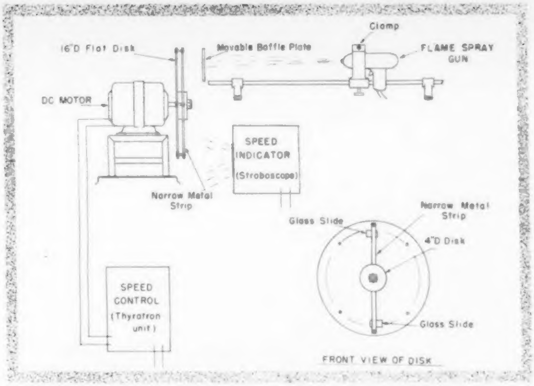
Surface Roughness

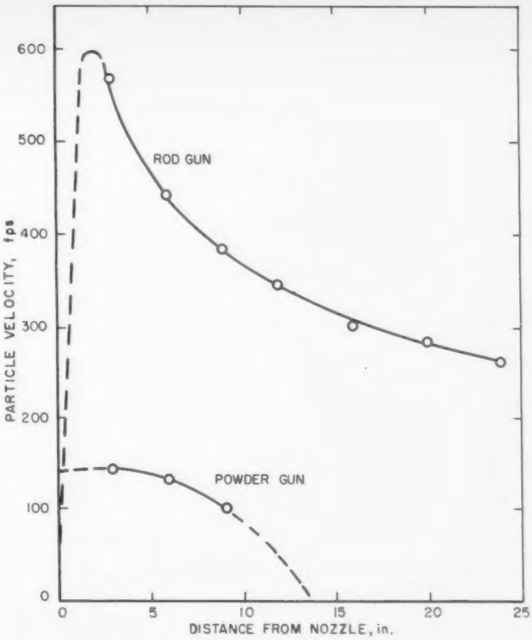
The experiments have shown that the strength of the bond formed between alumina and iron increases exponentially with increase in surface roughness of the substrate. In order to measure bond strengths, metal strips were roughened to various degrees by different blasting treatments and mounted between two knife edges so that a 0.05-in. length of each strip projected beyond the tips. Both sides of this projecting portion were spray-coated to a thickness of 0.010 ±0.002 in. The force required to shear the coating from the strip was then determined by pulling the coated section through the gap between the knife edges. The sprayed particles of alumina did not adhere to metal strips that had been polished. The measured bond strengths for surfaces that had undergone severe roughening were many times greater than for surfaces that had received only mild roughening treatment. Also, bond strengths for coatings formed with the rod gun were greater than for those formed with the powder gun.

Disk Velocimeter

A rotating disk velocimeter [1] was developed for determination of particle velocities. This device consists of a 16-in. metal disk, with a narrow metal strip attached by means of posts which support it at a known distance from the surface of the disk. A glass slide is attached to the disk in a position where it will be partially shielded from

A. W. Crigler directs molten alumina particles from an oxy-acetylene gun against a rotating disk velocimeter. The disk is sprayed while rotating at known speed, and the particle velocity determined from the offset of a "shadow" formed by a narrow strip attached to the face of the disk.





Left: Rotating disk velocimeter. The baffle plate is removed after the particle stream is adjusted. Right: Average particle velocity at increasing distances from the guns. High-pressure air is forced into the rod gun, giving the particles a higher velocity than that produced by the powder gun.

the sprayed particles by the narrow metal strip. When this slide is sprayed with the molten alumina, the strip creates a "shadow" in the layer of particles that adhere to the slide. The slide is first sprayed while the disk is at rest, and then when it is rotating at known speed. The displacement between the two "shadows" formed on the slide is a function of the particle velocity. The particles from the rod gun had a measured peak velocity of 566 ft/sec, and those from the powder gun, 145 ft/sec.

Particle Temperature

No direct method was devised for determining the temperature of the small, fast-moving particles; however, the appearance of the particles after impact gave an indication of their consistency at the instant of contact. Glass slides were sprayed while maintained at various distances from the guns, and the particles that adhered were examined microscopically.

From the patterns produced by the particles when they deformed upon impact, it was determined that at 2 in. from the powder gun most of the particles were molten only on the outside; at 4 in. practically all of the droplets were completely molten; and at 6 in. only the cores were molten. Particles that are completely molten at the time of impact adhered more readily than the others. The rod-gun particles, because of their higher velocity, flowed more on impact than did the powder-gun particles.

Cooling Characteristics

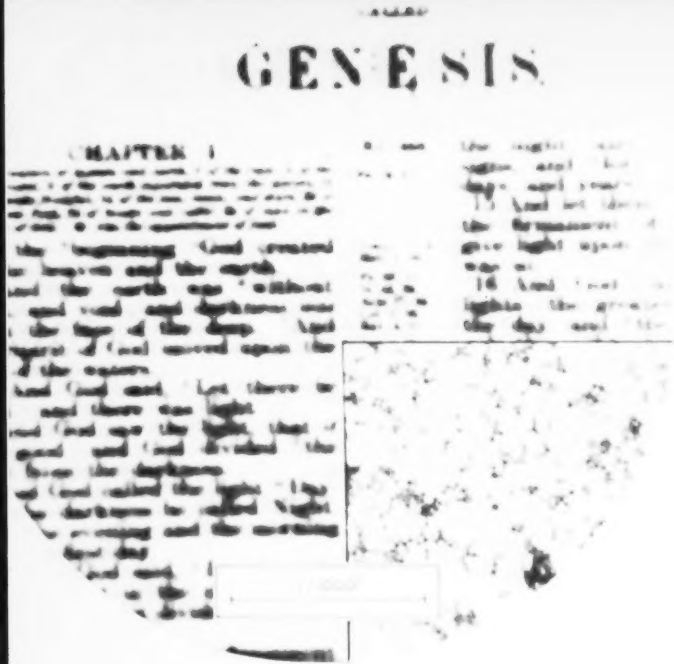
The thermal properties of a material influence the flow of molten particles immediately following impact. When the adhering particles cool more slowly, as they do on glass, flow continues for a longer time than when the cooling rate is very rapid, as it is on platinum. Cooling rates were calculated for a thin layer of molten alumina striking the surfaces of various materials at room temperature. The initial cooling rate of molten alumina on glass (2,050 to 1,800 °C) was computed to be 34,000 °C/sec, and on stainless steel, 800,000 °C/sec. Experiments with heated platinum substrates indicated that the ratio of alpha and eta alumina in solidified particles is dependent upon the quenching rate, and that the formation of the metastable eta form is favored by rapid quenching.

Nature of the Bond

When a particle strikes glass it cools less rapidly than when it strikes metal, thus allowing more time for a chemical bond to form. To indicate whether slower cooling would also give a chemical bond with metal, augmenting the mechanical bond, a strip of iron was coated with porcelain enamel, which in turn was covered with a 0.0003-in. layer of nickel. The ceramic substrate effectively lowered the cooling rate of the sprayed particles, but the bonding was not improved.

On glass good bonding occurred whether the surface was rough or smooth, but on iron the bond strength was substantially increased by roughening the surface. These results suggested that the bond between the alumina coating and glass substrate is largely chemical, but that the bond formed between flame-sprayed alumina and metals is principally mechanical in nature.

[1] **Velocity measurements of flame-sprayed alumina oxide particles,** ***by D. G. Moore, W. D. Hayes, Jr., and A. W. Crigler, Wright Air Development Center Report 59–658, Part I.***



Photomicrographs, taken through the same high-powered microscope, compare the size of letters in a microcopy made with the new research camera with the size of some common bacteria. The camera was designed for use in measuring the ability of photographic materials to resolve fine detail. When the microcopy is viewed directly through the microscope, the main text is clearly legible while the chapter summary is not. (The bacteria staphylococcus aureus, were prepared by the National Institutes of Health during a study of various vaccines.)

High-Resolution Camera

A RESEARCH CAMERA capable of projecting a parallel line pattern of 50,000 lines per inch has been developed at the Bureau. The camera, designed by C. S. McCamy of the photographic research laboratory, is a step toward the development of a standard method for determining the resolving power of photographic materials.

At the present time, there is no standard method for measuring resolution. The Bureau's work is part of efforts by a committee of the American Standards Association to establish such a standard. Five laboratories in the United States and Canada are working on methods which can be employed. By comparison of results, they will be able to determine the factors which must be specified in order that all resolution tests on the same film or plate may yield the same result.

To insure that any limitations revealed by the test are those of the photographic materials and not of the test equipment, the camera must be able to produce a line pattern much finer than can be resolved by the emulsion being tested. To test the new camera's full capabilities (50,000 lines per inch) it was necessary to use extremely high-resolution spectographic plates having a film speed of 0.025 when rated on the ASA scale for pictorial negative materials.

The camera's optical system is essentially a fine apochromatic microscope system operated in reverse to make an extremely small image of a large chart. The camera has interchangeable lenses. Objectives in use are an 8-mm lens having a numerical aperture of 0.65, which is equivalent to an *f*-number of 0.77, and a 16-mm lens having a numerical aperture of 0.30 or an *f*-number of 1.66. For this application the elements of the objectives were respaced and the interiors of the lens mounts were specially blackened to minimize reflections.

Film or plates to be tested are placed against a surface attached to the objective lens mount by a fine screw thread, with a gear mechanism permitting minute adjustment of focus. Films are held in place by a miniature vacuum back. The focus is first set by direct visual observation with a microscope. Several exposures are then made, setting a slightly different focus each time, until the position of best focus is found. The camera is operated at a constant temperature to avoid changes in focus resulting from the thermal expansion or contraction.

To secure even illumination of the targets to be photographed, a compensator plate is placed between the lamp and condensers of the camera's illuminating system. The compensator is a glass sheet with a circular pattern printed on it—heavier at the center than at the edges—which counteracts the tendency of the condensers to give higher illumination at the center of the beam. Provision has been made to place filters, either color temperature-correcting filters or neutral density filters, between the illumination and the test chart. Color-correcting filters are used to adjust the illumination for the particular emulsion being tested. Neutral density filters are used to obtain a series of exposures of varying illuminance. The maximum resolving power obtained in the series is reported.

One important consideration in photographing the fine line patterns is to eliminate mechanical vibrations which could blur the photographs. To this end, the camera, including test chart, illumi-

nator, shutter, and optics, is encased in a massive steel cylinder. The cylinder, in turn, is suspended from the ceiling by springs. The vibrations naturally present in the building were determined to be mainly 30 cps, 60 cps, and 120 cps; since the springs used for support have a natural frequency of approximately 2 cps, an effective mechanical insulation is achieved.

The new camera was used in an experiment to test the generally accepted correlation between resolving power and legibility at an extreme reduction ratio. In addition, the photograph made shows the extremely fine detail which may be recorded by this system.

In this experiment, Bernard Fouquet of the photographic research laboratory made a photocopy of the first page of the Bible at a linear reduction ratio of 1,000, thus reducing the area by a total factor of 1,000,000.

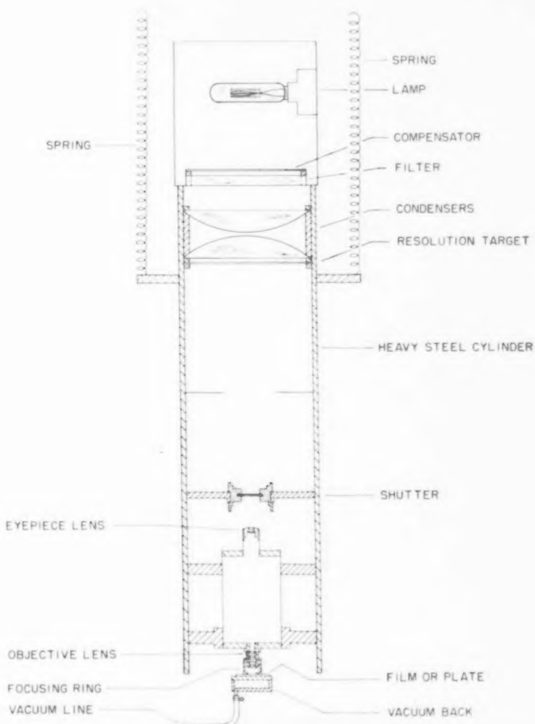
The page was first reduced 2.5 times to fit it into the camera's chart holder; then it was reduced by a factor of 400 with the new camera. If the entire Bible could be reproduced at this reduction ratio, it would cover no more than ¼ cm², less than the area of Lincoln's head on a penny.

The microcopy was made on a high-resolution spectrographic plate using an exposure of 10 sec at $f/0.77$. It is clearly legible when viewed directly at a magnification of 1,250 through a fine optical microscope. Blue light is used to view the microcopy since a short wavelength enhances resolution.

The Bureau does not recommend this method for routine microcopying. Because of the difficulty in focusing, the problem of keeping dust from the field, the long exposures involved, and the difficulty of viewing the copy, the method is too tedious for routine use.

Since one of the main purposes of the undertaking was to develop a standard method of measuring resolving power of photographic materials, the materials and components used were deliberately limited to those generally available. Somewhat better performance might be realized if this limitation were relaxed. Much more work remains to be done before a method can be standardized.

Bernard Fouquet operates the new research camera as C. S. McCamy, designer of the camera, looks on.



Internal components of a new research camera capable of projecting parallel line patterns as fine as 50,000 lines per inch. The camera was designed for use in measuring the ability of photographic materials to resolve fine details.

574984 O - 60 - 2

INFRASONIC waves generated in the earth's atmosphere by earthquakes, pressure disturbances from tornadic storms, and geomagnetic disturbances have been recorded at the Bureau. For what is believed to be the first time, studies were made of the quantitative relation between the source of the disturbance and the incident sound pressure, the direction of approach of the incident wave, and the speed of the wave across the earth's surface (usually called the trace velocity or the horizontal phase velocity). These studies were begun under the direction of the late Peter Chrzanowski, and are being continued by the Sound Section staff.

A system of detectors of the type employed by the Bureau near its Washington laboratories could be used to follow the paths of tornadic disturbances and to supplement knowledge of upper atmospheric physics, especially with respect to the sun's effect on the earth's magnetic field. Also of interest are very-low-speed pressure waves which may be gravitational waves resulting from shifts among atmospheric layers of varying temperatures or wind speeds. The Bureau is planning for a sound-recording installation similar to that in Washington to be located near Boulder, Colo.

Although the atmosphere may sometimes seem relatively free from audible sounds, natural sounds of substantial intensity are always present. These sounds are propagated through the atmosphere at infrasonic frequencies—frequencies lower than the human auditory threshold of about 15 cps. In a homogeneous atmosphere free of winds

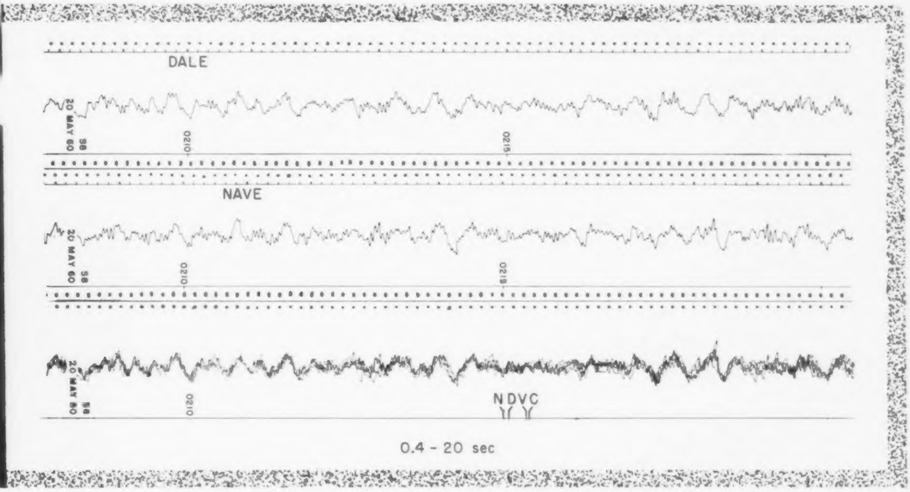
Unusual Recordings of
Infrasonic Dis

and temperature variations, the speed of sound varies as the product of the square root of the absolute temperature and a constant related to the medium through which the sound travels, and is equal to the frequency times the wavelength. The rate at which sound power is absorbed and dissipated into heat is a strong function of frequency; the fraction of sound power absorbed per unit distance of propagation is roughly proportional to the square of the frequency. The net effect of this relation is that only sounds having very low inaudible frequencies can be propagated great distances.

One of the first natural sounds observable at great distances resulted from the tremendous explosion of the volcano Krakatoa in 1883 in the East Indies. At that time, electronic equipment suitable for detection of such waves did not exist, but inaudible sound waves from this disturbance traveled around the world several times with a pressure so great that readable deflections were produced on barographs. A similar occurrence was the impact of the great Siberian meteor in 1908.

D.M. Caldwell calibrates an infrasonic microphone, which is connected by a hose to the calibrating barrel. An oscillating piston (top of barrel) produces an accurately known sound pressure in the barrel at various low frequencies. The metal barrel is padded on the outside to reduce thermal effects.

Left: How infrasonic waves issuing from tornadic disturbances in the central United States might be propagated to the Bureau's detection, measurement, and recording system. Below: Acoustical signals received at the NBS Washington laboratories from tornadic storms of May 20, 1960.



of

isrbances in the Atmosphere

About the time of World War I, it became apparent that the sound propagated by cannon fire could be heard within a radius of 100 km of the source and often beyond 200 km, but not between 100 and 200 km from the source. This anomalous effect was interpreted correctly as due to reflection of sound waves from a layer of air in the upper atmosphere in which the speed of sound was greater than at sea level. Such an interpretation required that the reflecting layer be at a higher temperature than the air at ground level.

By listening for the lowest audible frequencies, these early observers deduced the height and temperature of the reflecting layer from a consideration of the "skip" distances for sound propagation combined with a knowledge of the total transit time from the source to the observer. The temperature structure of the atmosphere that resulted was subsequently confirmed by observations of the heights at which meteors disappeared, and most recently by direct observations of the upper atmosphere with instrumented rockets.

About 10 years ago, the Bureau began development of a microphone and recording system for studying very-low-frequency sounds in the atmosphere. The present version is unusually reliable and flexible and is calibrated easily. Band-pass filters can be introduced into the amplifiers when a higher signal-to-noise ratio is desired for the sound under study. Earthquake waves, for example, are best studied with a band-pass filter passing sounds having periods between 0.4 and 20 sec. The system consists of four microphones located at ground level, approximately in the same plane. Effects on each microphone of pressure fluctuations due to local turbulent wind conditions are minimized by noise-reducing pipe lines about 300 m long, similar to those described by Daniels.[1] For sound waves of periods greater than about 10 sec, this antenna is essentially nondirectional and does not attenuate the sound pressure appreciably. However, noise due to random pressure fluctuations in the period range from 1 to 30 sec, such as that caused by wind turbulence, is reduced considerably.

The microphones produce frequency-modulated voltages proportional to the incident sound pressures. These voltages are transmitted by telephone wires to a central location, where they are demodulated, amplified, and recorded as ink-on-paper traces. When a sound wave of sufficient magnitude is present, similar traces are produced on each of the four paper records. The direction of approach of the wave and the trace velocity are obtained by comparing the different times of appearance at the four microphones. Wind pressures are also recorded, but such effects are purely local to each microphone installation.

Earthquake Waves

One natural sound occasionally observed is that radiated into the atmosphere by an earthquake wave as it proceeds over the earth's surface. This surface may be likened to the diaphragm of a loudspeaker, with vertical motions giving rise to sound radiations. Since the speed of the earthquake wave is much greater than the velocity of sound in air, the radiations are propagated upward in a direction almost perpendicular to the earth's surface.

Sound pressure produced by the great earthquake in Montana on August 18, 1959 was observed at the Bureau's Washington laboratories. The shear waves of the earthquake arrived from the northwest with a period of 11 sec and a trace velocity of 6.0 km/sec. The earth's displacement deduced from a peak-to-peak sound pressure of 0.8 dyne/cm^2 was 0.34 mm. Rayleigh waves on the earth's surface arrived later from west-northwest with a period of 15 sec and a trace velocity of 3.8 km/sec. The earth's displacement calculated from the peak-to-peak sound pressure was 3.0 mm.

An interesting property of these acoustical measurements is that the sound pressure at any point is a measure of the average displacement of the earth over a considerable area in the vicinity of the point. A seismometer measurement, on the other hand, is of the earth's displacement only at the point at which the instrument is located.

Tornadic Storms

A natural sound observed in Washington when the background noise is low appears to originate in the vicinity of severe tornadic storms up to 1,200 mi away in the central United States. Weather Bureau reports of May 5, 1960 show 19 tornadoes and funnel clouds in Oklahoma and

A plot of the spread in measured directions from which accoustical waves arrived during a 4¼-hr interval on May 5, 1960. The spread of the measured directions encompasses the geographical locations (enclosed area) of tornadoes reported by the Weather Bureau during the corresponding time period.

J. M. Young checks an infrasonic microphone, which is in a thermally insulated can at an outdoor microphone station. The hose connects the microphone to the noise-reducing pipe line.

Texas and 1 tornado in northwestern Kansas that could have produced the sound waves received at Washington during a 4¼ hr interval on that date. Similar waves believed to be from tornadic storms were received during eight such time intervals in May 1960. Properties characteristic of such tornadic signals on arrival are periods between 12 and 50 sec, speeds about equal to that of sound in air, and sound pressures normally less than 1 dyne/cm^2 at these distances.

Magnetic Storms

Another natural sound source is associated with geomagnetic storms—disturbances of the earth's magnetic field resulting from interactions of the field with particle streams from the sun. The existence of such a source strongly suggests that these interactions involve the upper atmosphere. These waves are mostly in the low-frequency range (periods greater than 20 sec), have a trace velocity usually greater than the speed of sound—sometimes as much as three times as great, and usually arrive from the north with pressures of roughly 1 to 3 dynes/cm^2. Their high trace velocity across the surface of the earth indicates that the waves arrive from above the earth at a large angle to the surface.

The high degree of association of these waves with large magnetic storms is significant. The direction from which these waves arrive varies with the time of day. It changes from northeast to northwest between noontimes, and is approximately northerly at midnight. Location of the origins of these strange sounds and measurement of their propagation constants should lead to a better knowledge of the properties of the atmosphere surrounding the earth.

[1] Noise-reducing line microphone for frequencies below 1 cps, *by Fred B. Daniels, J. Acoust. Soc. Am.* **31,** *529* (*1959*).

Laboratory Method for Measuring Tire Tread Wear

A LABORATORY method for measuring the rate of tire tread wear has been developed by the Bureau for the Army Ordnance Tank-Automotive Command. In this method, the tires are held against the inner surface of a cylindrical roadway that revolves at a selected speed for test runs of 500 miles or more. The variables present in road testing are thus rigorously controlled so that reproducible data may be obtained for comparing rates of tread wear of different tires.[1]

One of the most important performance characteristics of tires is tread wear, which generally is evaluated under actual road service conditions. However, these tests are expensive and time-consuming and sometimes show considerable variability in their results. A study was therefore undertaken by G. G. Richey, J. Mandel, and R. D. Stiehler of the Bureau staff, to devise a rapid, economical means of evaluation in which factors like slip angle,* speed, load, temperature, and inflation pressure could be controlled.

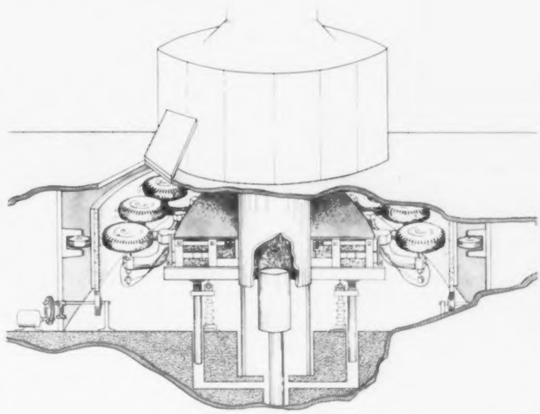
*Slip angles are produced under road service conditions of steering when the tires on a vehicle are turned to follow a curved path.

In the test equipment, a steel cylinder 28 ft in diameter, 3½ ft high, and lined with 3-in. thick concrete, is used for the revolving roadway. This cylinder, with its axis vertical, is supported by streetcar wheels that are operated by twelve 20-hp motors. The speed of the roadway can be varied up to 65 mph. Dust is applied to the roadway in measured quantities during tests to simulate service conditions. Tread wear is measured by weighing the tire, to the nearest gram, before and after the test run.

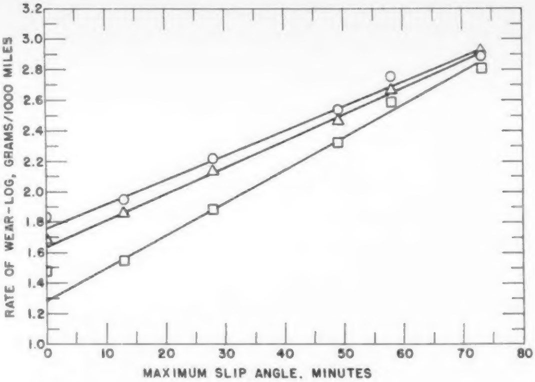
Around the inside of the roadway the tires are mounted horizontally on carriages that extend out from a central platform. The air spring assemblies that apply the load are mounted on this platform, which may be mechanically raised and lowered to permit the tires to traverse the roadway. When load is applied, the carriages move radially to force the tire treads against the concrete surface of the roadway.

An eccentric, connected to the cantilever arm of each carriage assembly and rotated automatically at a speed of 1 rpm during the test, varies the slip angle in such a way that positive and negative slip angles of equal magnitude are obtained during each cycle. The temperature of the contained

Left: Typical tires ready for test in the equipment developed to measure tread wear. In the background is a portion of the cylindrical roadway, which runs on streetcar wheels. Below: Cutaway view (not drawn to scale) of the tire testing equipment.



Effect of slip angle on rate of tread wear for three different types (○, △, □) of tire construction. Solid lines represent the equation, log $W=A+B\theta$, where W is the rate of wear in grams per 1,000 miles, θ is the maximum slip angle in minutes, and A and B are parameters characteristic of the tire.



air in the tires is measured by a previously developed method, in which copper-constantan thermocouples are inserted in the tire valve stems.[2] An air hose connected to each valve stem through a rotary joint permits measurement and adjustment of inflation pressure during a test. A pneumatic switch in the air line causes retraction of the tire if the inflation pressure falls below a set value. Because of the independent control of the various measuring devices for each tire and carriage assembly, tires ranging in size from 6.70–15 passenger-car to 11.00–20 truck tires at different loads and inflation pressures may be included in a single run. The test equipment is enclosed in a chamber which is maintained at constant temperature. Hatchways in the floor above this chamber permit access to the tires.

Data from several tests indicate that slip angle and type of tire construction have pronounced effects on the rate of tread wear. The relation between rate of wear and slip angle was studied for a number of tires. It was found that wear increases exponentially with slip angle except for very small angles.

Outdoor road tests, conducted for comparison purposes, showed that the position of the tire on the vehicle, daily variations in test conditions, and the type of construction markedly affected the rate of tread wear. In an indoor test under comparable conditions, the relative rates of wear were in accord with those obtained in the outdoor tests.

From the data obtained thus far with the indoor equipment, it appears that this laboratory method gives rapid, reproducible results. Not only are measurements of tread wear possible with this method, but tire carcass durability also can be determined.

[1] *For further technical details see* An indoor tester for measuring tire tread wear, *by G. G. Richey, J. Mandel, and R. D. Stiehler, Proc. International Rubber Conf., Washington, D.C. (Nov. 1959).*

[2] Temperature studies of the air in a truck tire, *by G. G. Richey, R. H. Hobbs, and R. D. Stiehler, Rubber Age* **79**, *273 (1956); and* Direct measurement of tire operating temperatures, *NBS Tech. News Bull.* **41**, *76 (1957).*

Are Statistical Life-Testing Procedures Robust?

THE BUREAU has been evaluating the robustness of acceptance sampling procedures used in life-testing experiments. Procedures which can be used effectively when some of the underlying mathematical assumptions are not satisfied are termed robust. Recently, M. Zelen and M. C. Dannemiller of the statistical engineering laboratory made a study of four acceptance sampling plans[1] that are representative of life-testing procedures currently used in the electronics industry.

Almost all statistical life-testing techniques are based on the assumption that the times to failure of components in a life test follow the exponential distribution. Since in practice the probability distribution of failure times may not be exponential, it is important to determine the robustness properties of these statistical life-testing procedures; i.e., how well the procedures work when the exponential assumption is not satisfied. Robust procedures are particularly desirable in reliability prediction because the underlying mathematical properties of the observed phenomena may not be known.

The successful operation of any complex system is dependent upon the operation of each individual component in the system. Thus if components from a manufactured lot are to be incorporated into an electronic system, it is essential that a large proportion of the items have a minimum acceptable lifetime. Unfortunately, it is seldom feasible to assess the lifetime of each component or of even a large proportion of the components. Furthermore, in many instances when components are subjected to a life test, the testing procedure is completely destructive. When an acceptance sampling technique is employed, only a sample of items from the lot undergoes life testing. The resulting data on failure times serve as a basis for accepting or rejecting the lot.

The amount of testing necessary for a particular acceptance sampling plan depends on:

(1) The probability of rejecting components having the desired average or mean failure time (producer's risk);

(2) the probability of accepting components having a specified below-par mean failure time (consumer's risk).

These probabilities are assigned so as to safeguard both the producer's and the consumer's interests. The consumer desires that the chance of accepting poor quality items be small; while the producer must be reasonably sure that good items will not be rejected. There is no guarantee, however, that the assigned risk levels will be maintained if the exponential assumption is false. If these risks are appreciably altered, the application of the acceptance sampling procedure may be disastrous to either the producer or the consumer.

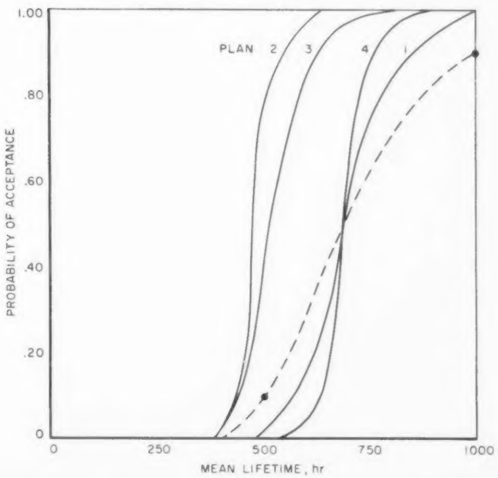
The four acceptance sampling plans which were investigated for robustness properties are:

(1) Fixed sample size plan—a sample of n components is tested until all fail;

(2) fixed sample size plan with censoring—a sample of n components is placed on test, and testing is discontinued after the rth failure ($r < n$);

(3) truncated nonreplacement plan—a sample of n components is placed on test and the testing discontinued after a preassigned time;

(4) simple sequential plan—the components are placed on test one at a time, and after each failure a decision is made to accept the lot, reject the lot, or continue testing.



Operating characteristic (OC) curves were computed for four acceptance sampling plans based on the exponential distribution when the failure times actually follow a particular Weibull distribution. If the exponential distribution applies, components having mean lifetimes of 1,000 and 500 hours are accepted with probabilities of 0.90 and 0.10, respectively. This is illustrated by the dashed line, which is the OC curve for plan 3 when the failure times come from an exponential distribution.

For any one of these acceptance sampling plans, the operating characteristic (OC) curve can be constructed depicting the mean failure time plotted against the probability of acceptance. This curve is well known when the distribution of failure times is exponential. If it can be shown that the operating characteristic curve is not appreciably changed when the failure times actually come from certain alternative distributions, then the sampling procedure is said to be robust with respect to the alternative distributions.

Three Weibull distributions with different shape parameters were chosen as alternative distributions for studying the robustness of the four acceptance sampling plans. The Weibull distribution belongs to a class of distributions which characterize "wear out" failure, e.g., the longer the item has been in operation, the greater the probability of failure. Further, it is difficult to distinguish between it and the exponential distribution for small sample sizes. This latter fact has special significance because the experimenter will rarely have enough data to enable him to decide which distributional assumption holds.

The exact operating characteristic curves for plan 3 were obtained from known theoretical results. On the other hand, the OC curves for plans 1 and 4 were calculated using special analytical approximations developed in the statistical engineering laboratory. The OC curve for plan 2 was calculated by simulating several thousands of life-test experiments on a computer.

The operating characteristic curves indicate that not one of the four acceptance sampling procedures is robust with respect to Weibull alternative distributions. The fixed sample size plan with censoring (2) and the truncated nonreplacement plan (3) are strikingly nonrobust because, for the particular choice of Weibull distributions in this study, components having a low mean failure time showed a high probability of acceptance. On the other hand, the fixed sample size plan (1) and the sequential plan (4), while not robust, are less sensitive to departures from the exponential assumption.

The study demonstrates dramatically the risks taken by an experimenter who adopts an acceptance sampling procedure without possessing sufficient knowledge of the underlying properties of the observed phenomena. The results further indicate the need for research leading to statistical methods for life testing that are insensitive to distributional assumptions. Development of robust methods is one of the goals of the Bureau's program of mathematical research into the prediction of the reliability of complex systems.[2]

---

[1] *For further information, see* The robustness of life testing procedures derived from the exponential distribution, *by M. Zelen and M. C. Dannemiller, Technometrics (to be published, Feb. 1961).*

[2] Mathematical research on reliability prediction, *NBS Tech. News Bull.* **44**, *24 (1960).*

NBS to Cooperate in New Institute of Measurement Science

THE George Washington University (Washington, D.C.) has announced the establishment of an Institute of Measurement Science. In making this announcement, Dr. Martin Mason, Dean of the School of Engineering, stated the University's hope that the new educational center will have a vital role in the technological support of the country's scientific progress and security.

The Bureau is cooperating with the University in planning and establishment of the institute; and the Martin Company of Baltimore, Md. is the first industrial firm to provide financial support for the new center. Other industrial concerns who are dependent on ultra-accurate standards and who feel the "measurement pinch" acutely, have also offered to assist in equipping and supporting an academic center for metrology, according to Dean Mason.

The Bureau's interest in a university program in precise physical measurements stems from a recognition of the growing need for both broad education and special training in this area of science. Increasing requests from industry for a source of talent to develop and use precise measurement techniques has resulted in a growing burden on the NBS staff for consultation. At the same time the work load of the laboratories has been growing rapidly in the area of testing and calibration services.

Modern technology depends on quality control which in turn demands precise measurement. The instruments and testing equipment used in the shops and laboratories of industry to insure reliability and interchangeability of precision components must themselves be checked against standards of high quality, related through a suitable chain of measurements, to the national standards maintained at the Bureau.

Founding of the new Measurement Institute resulted from informal discussions between representatives of industry, faculty members of the George Washington University School of Engineering, members of technical divisions of the Bureau, and representatives of the NBS Educational Committee. Curricula leading to undergraduate and advanced degrees have been planned; and course work will begin in February under the joint sponsorship of the George Washington University School of Engineering and the National Bureau of Standards Graduate School. Courses offered in the current academic year will include introductions to metrology and to the statistics of metrology, as well as specialized courses in heat, mechanical, and electrical measurements.

The Measurement Center at the George Washington University is believed to represent the first comprehensive and coordinated curriculum in measurement science offered at any American college. It is hoped that the new Institute will serve as a model, and that other universities throughout the Nation will be encouraged to include Metrology—the science of measurement—as part of their curricula.

October 7, 1960

Dr. Martin Mason, Dean
School of Engineering
The George Washington University
Washington, D.C.

Dear Dean Mason:

I was greatly pleased to hear of the announcement that The George Washington University will offer curricula in measurement science next February leading to an Associateship and the Bachelor's and Master's degrees.

I have believed for a considerable time that special education at the university level in the field of precise measurement is required to meet the demands of our rapidly expanding and highly complex technology. The National Bureau of Standards has been cooperating for many years with various groups in American industry to improve methods of measurement and to instruct professional personnel in the application of them. However, I have never felt that such instruction was an adequate substitute for formal college training in the field.

In undertaking this program which is novel in the educational field you will be confronted with many problems and difficulties. I promise you my full personal support and cooperation, and I know, from the sentiments expressed to me, that you can be assured of the same from many members of the staff of the Bureau.

It is gratifying to learn that this project has also found favor among those groups in American industry which will benefit most from its successful prosecution. The firmness of their support is demonstrated by the financial and other material aid already received or promised.

The staff of the Bureau joins me in wishing the greatest success for this endeavor.

Sincerely yours,
Allen V. Astin,
Director.

Index to Technical News Bulletin—Volume 44, 1960

I

J

K

L

M

N

O

P

R

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Volume 45, No. 11, November 1960. 15 cents. Annual subscription: $1.50, 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Basic Radio Propagation Predictions for February 1961. Three months in advance. CRPL–D195, issued November 1960. 15 cents. Annual subscription $1.50, 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards.

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign $2.75.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

Section D. Radio Propagation. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Section A, Physics and Chemistry, Volume 64A, No. 6, November-December 1960.

The spectrum of singly ionized atomic iodine (I II), W. C. Martin and C. H. Corliss.

The third spectrum of gold (Au III), L. Iglesias.

Tolerances for layer thicknesses in dielectric multilayer coatings and interference filters, K. D. Mielenz.

Note on particle velocity in collisions between liquid drops and solids, O. G. Engel.

Resistance of white sapphire and hot-pressed alumina to collision with liquid drops, O. G. Engel.

Note on the thermal degradation of polytetrafluoroethylene as a first-order reaction, S. L. Madorsky and S. Straus.

Heat of formation of titanium trichloride, W. H. Johnson, A. A. Gilliland, and E. J. Prosen.

Heat of formation of decaborane, W. H. Johnson, M. V. Kilday, and E. J. Prosen.

Ultra low-conductivity water by electrophoretic ion exclusion, W. Haller and H. C. Duecker.

Spectrophotometric determination of the ionization constant of dimethylpicric acid (2, 4, 6-trinitro-3, 5-xylenol) in water at 25° C, M. M. Davis, M. Paabo, and R. A. Robinson.

Spectrophotometric determination of the ionization constant of 2, 4, 6-trinitro-*m*-cresol in water at 25° C, M. M. Davis and M. Paabo.

Method for the separation of titanium, zirconium, iron, and aluminum from one another and for their subsequent determination, T. J. Murphy, W. S. Clabaugh, and R. Gilchrist.

Section B, Mathematics and Mathematical Physics, Volume 64B, No. 4, October-December 1960.

Magnetic polarizability of a short right circular conducting cylinder, T. T. Taylor.

Accuracy of Monte Carlo methods in computing finite Markov chains, N. W. Bazley and P. J. Davis.

Error bounds in the Rayleigh-Ritz approximation of eigenvectors, H. F. Weinberger.

Sequence transformations based on Tchebycheff approximations, J. R. Rice.

Numerical solution of the frequency equations for the flexural vibration of cylindrical rods, W. E. Tefft.

Section C, Engineering and Instrumentation, Volume 64C, No. 4, October–December 1960.

Error analysis of a standard microwave phase shifter, G. E. Schafer and R. W. Beatty.

A method of controlling the effect of resistance in the link circuit of the Thomson or Kelvin double bridge, D. Ramaley.

Automatic precise recording of temperature, G. S. Ross and H. D. Dixon.

17

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

Publications (*Continued*)

Gimbal device to minimize the effects of off-center loading on balance pans, H. A. Bowman and L. B. Macurdy.
Response of microchemical balances to changes in relative humidity, H. E. Almer.
Chemical changes occurring during the weathering of two coating-grade asphalts, S. H. Greenfeld.
Characteristics of fifteen coating-grade asphalts, S. H. Greenfeld.
Section D, Radio Propagation, Volume **64D**, No. 6, November–December 1960.
URSI National Committee Report:
- Commission 1. Radio measurement methods and standards.
- Commission 2. Tropospheric radio propagation.
- Commission 3. Ionospheric radio propagation.
- Commission 4. Radio noise of terrestrial origin.
- Commission 5. Radio astronomy.
- Commission 6. Radio waves and circuits.
- Commission 7. Radio electronics.

Nonperiodicals

Heat treatment and properties of iron and steel, T. G. Digges and S. J. Rosenberg. NBS Mono. 18 (1960) 35 cents. (Supersedes C495.)
Specific heats and enthalpies of technical solids at low temperatures. A compilation from the literature, R. J. Corruccini and J. J. Gniewek. NBS Mono. 21 (1960) 20 cents.
Household weights and measures. NBS Misc. Publ. 234 (1960) (Supersedes M39) 5 cents.
Screw-thread standards for federal services, 1957. Amends in part H28 (1944) (and in parts its 1950 Supplement). NBS Handb. H28 (1957)—Part III (1960) 60 cents.

Technical Notes

The following Technical Notes are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (Order by PB number.)
Transistorized building blocks for data instrumentation, J. A. Cunningham and R. L. Hill. NBS TN68 (PB161569) (1960) $2.00.
Quarterly radio noise data—June, July, August 1959, W. Q. Crichlow, R. D. Disney, and M. A. Jenkins. NBS TN18–3 (PB151377–3) (1960) $1.00.
Quarterly radio noise data—September, October, November 1959, W. Q. Crichlow, R. D. Disney, and M. A. Jenkins. NBS TN18–4 (PB151377–4) (1960) $1.50.
Calibration of five gamma-emitting nuclides for emission rate, J. M. R. Hutchinson. NBS TN71 (PB161572) (1960) 75 cents.
Table of magnitude of reflection coefficient versus return loss$\left(L_R=20\log_{10}\frac{1}{|\Gamma|}\right)$, R. W. Beatty and W. J. Anson. NBS TN72 (PB161573) (1960) $1.25.
VHF and UHF power generators for RF instrumentation, A. H. Morgan and P. A. Hudson. NBS TN77 (PB161578) (1960) 75 cents.

Publications in Other Journals

Microwave spectrum of trans-crotononitrile, V. W. Laurie, J. Chem. Phys. **32**, No. 5, 1,588 (1960).
Tropospheric fields and their long-term variability as reported by TASO, P. L. Rice, Proc. IRE **48**, 1,021 (1960).
On the power of some rank-order two-sample tests, J. R. Rosenblatt. Book "Contributions to Probability and Statistics," Paper 32, p. 358 (Stanford Univ. Press, Stanford, Calif., 1960).
Disc distribution of flares associated with certain radio bursts, C. Warwick, Proc. Symp. Physical Processes in the Sun-Earth Environment, July 20–21, 1959 (Ottawa, Defense Research Telecommunications Establishment), DRTE Pub. No. 1025, 249 (1960).
Effect of tensile properties of reinforcement on the flexural characteristics of beams, R. G. Mathey and D. Watstein, J. Am. Concrete Inst. **31**, No. 12, 1,253 (1960).
The ionization potential of fluorine, J. T. Herron and V. H. Dibeler, J. Chem. Phys. **32**, No. 6, 1,885 (1960).
The intensity of [OI] 5577 in the subauroral region as a function of magnetic activity, F. E. Roach, J. Geophys. Research **65**, No. 5, 1,495 (1960).
Valences of the elements in analytical procedures, J. I. Hoffman, Chem.-Anal. **49**, No. 1, 30 (1960).
A comparative study of absolute zenith intensities of [OI] 5577, F. E. Roach, J. W. McCaulley, E. Marovich, and C. M. Purdy, J. Geophys. Research **65**, No. 5, 1,503 (1960).
Our measurement system and national needs, A. V. Astin, Sperryscope 15, No. 6, 16–19 (1960).

Patents

The following U.S. Patents have recently been granted on inventions covered in applications filed by NBS and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.

2,945,220	**July 12, 1960. Analogue-Digital Converter. Arnold Lesti and Andrew R. Baechtel.**
2,945,922	**July 19, 1960. Micro-Adjustable Switch. Ray K. Bryan (License).**
2,946,046	**July 19, 1960. Magnetic Digital Computer Circuit. Ephraim W. Hogue.**
2,953,774	**September 20, 1960. Magnetic Core Memory Having Magnetic Core Selection Gates. Ralph J. Slutz.**
2,955,246	**October 4, 1960. Low Capacitance Power Supply. John H. Reaves.**
2,955,467	**October 11, 1960. Pressure-Type Tide Recorder. Douglas L. Parkhurst (License).**
2,958,216	**November 1, 1960. Resonant-Beam Calibrator Thomas A. Perls and Charles W. Kissinger.**

Publications for which a price is indicated (except for Technical Notes) are available only from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

U. S. GOVERNMENT PRINTING OFFICE: 1960 O - 574984

ID

re-
)).
R.
nd
n-

lio
in
va,
t),

ex-
D.
)).
nd

a
ys.

I.

of
ch,
03

in,

ed
nd,
of

er.

ay

ir-

ry
ph

p-

Re-

or

for
n-
ce,
li-
3S
om

in